NATIONAL BUREAU OF STANDARDS REPORT

10 129

AN EVALUATION OF TWO FARR DYNA VANE SYSTEMS AT THE OMAHA MAIN POST OFFICE

Final Report to
Bureau of Research and Engineering
Post Office Department
Washington, D. C. 20260

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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AN EVALUATION OF TWO FARR DYNA VANE SYSTEMS AT THE OMAHA MAIN POST OFFICE

by

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Summary

Measurements were made on two operating Dyna Vane systems at the Omaha Main Post Office. One system was located in a shakeout area and operated at an average dust arrestance of about 50 percent by weight. The other was located in a sack routing center and operated at an average dust arrestance of about 24 percent. Both arrestance values, particularly the latter, might be improved if airflow in the exhaust duct were increased by auxiliary means. These systems were less effective in removing lint than other particulate matter in the 2 to 50 micrometer size range.

The principal cost of maintaining a Dyna Vane system is the labor required for periodic cleaning of louvers and exhaust ducts. It is estimated that the cost for routing the dust into a roll filter would be substantially less than the operating cost of a Dyna Vane system. However, these estimates assume that the roll filter is operating independently of any air conditioning system just as the Dyna Vanes are. Otherwise, there might be some additional cost of cleaning coils and components if the extra dirt load were routed into the filters of an air conditioning system.

Indirect costs in heating, air conditioning, and electric power would also be less for the roll filter. The two Dyna Vane systems tested, exhausted 210 and 375 cfm of conditioned air to the outside when operated, and the static pressure drop across the systems was 1.6 to 1.8 in. W.G. Roll filter systems do not exhaust air to the outside and usually operate on a static pressure drop of from 0.5 to 0.6 in. W.G.

1. Introduction

The Farr Dyna Vane is a device for removing coarse dust from air. Four of these units are in operation at the Main Post Office in Omaha, Nebraska, in areas where large amounts of dust and lint are generated in mail handling operations. The purpose of this study was to determine the effectiveness of these devices in a Post Office environment and to estimate their operating cost in comparison with other air cleaners such as roll filters.

To evaluate the systems, dust arrestance was measured, and the average concentration of dust and lint in the various branches of the systems and in the work areas was determined. An attempt was also made to determine the operating cost of a Dyna Vane system. The principal operating cost arises from the periodic cleaning which is necessary for effective operation. The Plant Maintenance Division of the Omaha Post Office provided an estimate of time required to clean the devices, and an estimate of operating cost was developed from this.

2. Description of Dyna Vane Units

The Dyna Vane is an air cleaning device which operates on an inertial principle. It is illustrated by the diagram and accompanying description from Farr Company "Dyna Vane Manual" F-190-B which is presented as Figure 1 in this report. The larger particles in the moving airstream as shown in the diagram have sufficient momentum to be carried into the bleed duct and exhausted out-of-doors instead of passing back through the louvers with the "clean" airstream.

Dyna Vane 1B and the shakeout area which it serves are illustrated in Figures 2 through 5. Figure 2 shows the shakeout area where the dust is generated when the mailbags are emptied and their contents are placed on the conveyor belt at the lower right in the picture. Figures 3, 4, and 5 show the ducts carrying air to and from the Dyna Vanes. Dyna Vane 2B and its ductwork are illustrated in Figures 6 through 9.

3. Performance of Dyna Vanes

A. General operating characteristics

The rates of airflow and static pressure in the different branches of the two Dyna Vane systems are given in Table 1. The average air velocity in the clean air duct is based on a nine point scan across the area of the duct with a hot wire anemometer. Due to the bend in the duct, the air velocity was much greater on the right side facing the airstream than on the left in both units. The average air velocity in the exhaust duct is based on a three point scan across the duct area.

As shown in Table 1 the air velocity in the exhaust ducts is less than in the main ducts. This is especially true of unit 2B. On a volume basis the exhaust flow in unit 1B is estimated to be 7.8 percent of the main flow while in unit 2B it is only 3.3 percent. Both are less than the 10 percent value mentioned in Farr Company literature on the Dyna Vane. According to Post Office plant maintenance personnel, the ducts had been cleaned 3 to 5 days before the measurements were made. Therefore, the low flow in the exhaust ducts, particularly in 2B, is either inherent in the design of the overall systems, or the exhaust ducts became loaded with dirt and lint very rapidly.

B. Dust concentrations and arrestance

a. Paper tape sampler[1] measurements

Measurements were made in Dyna Vane 1B with paper tape samplers[1]. One sampler was placed in the main duct ahead of the Dyna Vane, and the other was placed in the clean air duct. The results of the measurements are shown in Figure 10. The left part of the figure shows the optical density of 1-hour dust spots collected from these points over

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[1] The paper tape samplers used in these measurements were Gelman[2] model 23000 samplers. They draw air through paper tape for a preset period of time, after which a shift mechanism moves the tape and a new spot is started. A series of spots are obtained which are measured with a photometer and provide a record of relative dust level as a function of time.

[2] Certain commercial materials and instruments are identified in this report in order to specify experimental procedure adequately. Such identification does not imply recommendation or indorsement by the National Bureau of Standards, nor does it imply that the equipment or material is necessarily best for the purpose.

a 17-hour period. The optical densities are rather low considering the location from which the spots were taken, and there was little systematic difference between spots collected in the main and "clean" air ducts. The average arrestance over the 17-hour period was about -8 percent, indicating that slightly more dirt was collected from the "clean" air stream than from the main airstream.

Paper tape samples were then drawn from the "clean" air duct and the exhaust air duct. The results are shown in the right hand portion of Figure 10. The air in the exhaust duct was systematically a little dirtier than the air in the "clean" air duct.

As judged from paper tape sampler measurements shown in Figure 10, the Dyna Vane was ineffective in removing dirt from the air. However, paper tape measurements rate dust according to its surface area, and this assigns greater relative importance to fine particles. On the other hand coarse particles may represent a predominant part of the weight of the dust in a shakeout area. The Dyna Vane is a device for removing coarse dust from air. In subsequent tests a gravimetric method was selected to evaluate the Dyna Vane systems.

Although paper tape samplers are not ideally suited for rating low-efficiency air cleaning devices such as a Dyna Vane, they are useful to record rises and falls in dust level as a function of time. It was planned to use them concurrently during subsequent gravimetric tests, but they overheated early in the test and had to be shut off. The cause of this overheating has since been analyzed and is believed to have been due to failure of the motors to turn over because of low voltage. This condition was repeated in the laboratory and resulted in 3 to 4 times normal current consumption.

b. Measurement with high-volume samplers[3]

Air was sampled with high-volume samplers in each of the two Dyna Vane systems. Samples were taken from the main, "clean", and exhaust ducts of each of the units with the aid of probes which were directed into the center of the airstream. The samplers are shown mounted on

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3 General Metal Works model 2000[2] samplers were used in these measurements. These samplers draw air at rates of the order of 50-60 cfm through 8 x 10 inch high efficiency glass fiber filters. The collected dust is determined gravimetrically. The samplers are equipped with orifice plate flowmeters which permit measurement of sampling rates. These rates are integrated over the entire sampling time to obtain total volume of air sampled. In the present measurements when arrestance was determined, pressure recorders as well as the usual manometers were connected across the flowmeters as a check on fluctuations in sampling rates. For those samplers which drew samples from moving air, sampling probes with transitions were used to reduce the sampling area to slightly less than 2 x 2 inches and increase the sampling velocity to 1300-1700 ft./min. Samplers with transitions are shown in Figures 4 and 9. Samplers placed in the work area were used without sampling probes and transitions.

Dyna Vane 1B in Figure 4. In Dynavane 2B the main and "clean" air ducts were sampled by placing the entire sampler and sampling probe into the duct. Samples were also taken from a point in or near the working area served by each of the two Dyna Vane systems.

The samples collected with the high volume samplers are shown in Figure 11. They all contained considerable dirt, including the samples taken from the "clean" air duct. Quantitative estimates of the collected dirt and dirt concentrations are summarized in Table 2. The data were obtained with the Dyna Vane running full time. The results are undoubtedly somewhat dependent on the amount of activity in the work area during the time of sampling. The 1B unit was operating at an average arrestance of 50 percent by weight while 2B was operating at 24 percent arrestance. The difference in arrestance by the two units may have been due to the smaller airflow in the exhaust duct of unit 2B. This suggests that some improvement in dust arrestance might be obtained if the flow through the exhaust duct could be increased by an auxiliary fan or other means.

The average dust concentration in the main duct of each of the Dyna Vanes was higher than in the work area. This indicates that the systems have some effectiveness in collecting the generated dust. Also, more dust was found in the exhaust ducts than would be predicted from the differences in the amounts of dirt and airflows in the main and "clean" air ducts. This suggests that some accumulated dust may have been dislodged and collected in the sampler.

Lint was determined by removing most of the dirt from the filter and washing it with water through a No. 100 sieve and then through a No. 325 sieve. Most of the lint was collected on the first sieve. The percent lint in each of the samples is shown in Table 2. In both units this percentage was higher in the "clean" air duct than in the main duct, which suggests that the Dyna Vanes were less effective in removing lint than in removing other large dust particles. The fraction of lint in the dust collected in 1B was much higher than in 2B, although the total dust concentration was lower. The lint fraction was especially high in the exhaust ducts, which suggests accumulation and helps explain the need for periodic cleaning of the ducts.

The dirt and lint were slightly water repellent and required considerable mechanical manipulation to wet them thoroughly. Possibly this might be due to traces of oil in the form of droplets in the air. Microscopic examination of the collected material showed that practically no particles other than lint were retained on a No. 325 sieve which has a nominal opening of 44 μm[4]. Examination of the non-lint particulates indicated that most of the elementary particles were between 2 and 10 μm in diameter, while aggregates of larger size were present. These latter may have been produced in part by the washing and drying of the dirt in the analysis.

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[4] μm is the symbol for the International S.I. unit, micrometer, formerly micron (μ).

c. Viscous target measurements

Scotch tape targets, with the sticky surfaces facing into the airstream, were mounted vertically in the ducts. This method of sampling would predominantly capture coarser particles from the moving air stream. The targets were placed a foot or more ahead of the high volume samplers. In the main and "clean" air ducts the exposed tape was about 18 inches in length and 1 inch in width, while in the exhaust duct the length was slightly less than the height of the duct. After 21-24 hours all of the targets were highly coated with dust. Examination under the microscope indicated that the captured dust was predominantly lint with a few other particles having diameters from 10-50 μm. Photometer measurements were made at several points over the length of each tape, and average arrestance values were calculated. Arrestances of 29 percent for Dyna Vane 1B and 18 percent for 2B were obtained. This method of test has not been explored extensively, and possibly different values might have been obtained if shorter or longer sampling times were used. However, the results indicate considerable amounts of coarse dirt and lint were present in the "clean" air duct.

C. Estimates of Comparative Operating Cost of Dyna Vane and Roll Filter System

Periodic cleaning of the screens, louvers, and exhaust duct are the principle operating expense in maintaining a Dyna Vane system. According to estimates by the Plant Maintenance Division of the Omaha Main Post Office, 9-man-hours per week are spent in cleaning screens and louvers of four Dyna Vanes, and every 3-months 32-man-hours are spent in complete cleaning, which includes dismantling the exhaust duct and removing the dirt and lint. If these figures are divided by four, an estimate of 2 1/2 man-hours per week for screens and louvers and 8 man-hours per quarter for complete cleaning of each Dyna Vane is obtained. If it is assumed that the average wage of personnel performing the cleaning operation is \$3.97 per hour[5], this corresponds to nearly \$9 per week per Dyna Vane for cleaning screens and louvers and approximately \$32 every quarter for complete cleaning. This rate is represented graphically by the upper line in Figure 12, where quarterly cost has been distributed over a 13-week period and added to the other weekly cost, giving an overall estimate of slightly less than \$11 per week per Dyna Vane.

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[5] In a recent study of filter costs at the Philadelphia Main Post Office (NBS Report to Post Office, No. 10025, page 46), it was estimated that the average hourly wage of personnel who changed filters was \$3.78, which is slightly above the hourly rate for a PFS-7. The estimate of \$3.97 upgrades this figure to the fiscal 1970 pay scale.

For purposes of comparison, the current price of a 4-ft. fiber glass roll filter of the type used in many Post Offices is $24.90. If the installation cost is assumed to be $5, the cost of an installed filter is approximately $30. This, in effect, is paid in advance and is represented graphically in Figure 12 as a horizontal line. Horizontal representation assumes that the installation or changing of filters is the only maintenance cost other than the cost of the filter itself. If it is assumed that an additional 8 man-hours ($32) per quarter is required to clean the filter enclosure, this would be an additional cost, and the adjusted estimate is represented by the middle line in Figure 12. By inspection of the graph it may be seen that a 4-foot roll filter would have to last 3 to 4 weeks to break even with a Dyna Vane in operating cost.

Roll filter usage data for a 5-year period at the Philadelphia Main Post Office indicated that the length of service was quite variable, but an average value of about 20 weeks for a set of rolls was obtained when large amounts of data were taken into consideration. This estimate of filter life would be too high if the average dust concentration in a Dyna Vane is greater than the concentration at which these usage data were obtained.

Another cost estimate of roll filter and Dyna Vane operation may be obtained by estimating the amount of dust handled by a Dyna Vane and comparing it with the dirt collected by a roll filter. If it is assumed, from rounded estimates of data from Tables 1 and 2, that a Dyna Vane handles 6000 cfm at an average dust concentration of 30 micrograms per ft^3, this corresponds to about 1800 grams a week. For comparison with this figure, analysis of dust collected by roll filters at the Philadelphia Post Office suggests $30g/ft^2$ may be used as a representative estimate. If it is assumed the usable area of a 4-ft. roll is $3.5 \times 60 = 210\ ft^2$, this corresponds to 6300 g of dirt which is about 3 1/2 times the amount of dust entering a Dyna Vane in a week. However, if the filter were operating at a dust arrestance of 25 percent, a figure comparable with the 2B Dyna Vane, this corresponds to 14-weeks of operation. From Figure 12 the cost of operating a roll filter 14-weeks would be less than half the cost of operating a Dyna Vane.

The foregoing estimates are based upon a Post Office environment in which the lint content is higher than average. It is possible that a Dyna Vane might require less cleaning in a low lint environment, and these estimates would have to be revised. Also, if dirt from a shakeout area is passed into a preexisting roll filter which is part of an air conditioning system, this may require added expenditure for cleaning coils. This is not considered in Figure 12.

On the other hand, there are energy considerations unfavorable to the Dyna Vane which are not considered in the figure. For example, the Dyna Vanes require at least a 1-inch greater pressure drop than a roll filter. This would require approximately an additional 1-horsepower to do the extra pressure-volume work in a 6000 cfm unit, and the actual difference in power requirement would be greater than this depending upon the efficiency of the fan. Another energy consideration is that the Dyna Vanes exhaust roughly 300 cfm conditioned air to the outside. If there were a 40 °F temperature difference between the inside and outside temperature, for example, this would correspond to nearly 13,000 Btu per hour. With roll filters this heat would be conserved. Figure 12 considers only the direct costs of operating air cleaning units, while these latter costs would be hidden in heating, air conditioning, and lighting bills.

D. Acknowledgements

The author is indebted to Mr. Nehri Gulati of the Post Office Department for setting up the program for evaluation of the Dyna Vanes and for assistance in its execution. He gratefully acknowledges the assistance of the late Mr. Lewis A. Tomes in preparing data and constructing accessory apparatus used in the measurements. He is also indebted to Mr. James Wardian, Chief of the Plant Maintenance Division of the Omaha Post Office and Mr. Montgomery for their cooperation in the study and to Mr. Lonnie Morrow and Mr. Ron Jenson for assistance in setting up measurements at the Omaha Post Office.

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Table 1

Air Velocities and Static Pressures in Dyna Vane Units 1B and 2B

	1B	2B
Average Air Velocity - ft/min.		
"Clean"	1330	1220
Exhaust	1100	475
Main	1440*	1460*
Duct Areas - ft^3		
"Clean"	3.33	5.00
Exhaust	.34	.44
Main	3.33	4.33
Volume Flow Rate - cfm		
"Clean"	4420	6100
Exhaust	375	210
Main	4795*	6310*
Static Pressure - in. W.G.		
"Clean"	zero at exit	
Exhaust	0.85	0.89
Main	1.6 - 1.7**	1.8

* Based on sum of clean and exhaust volume flow rates.

** Considerable fluctuation due to air turbulence.

Table 2

Analysis of Dirt Removed from Work Spaces at Omaha

Post Office by Dyna Vane Systems 1B and 2B

	Main duct	"Clean" duct	Exhaust duct	Work area
Unit 1B				
Total dust collected (23.5 hrs.) g	0.995	0.500	12.214	0.530
Percent lint	31	36	79	23
Total air sampled - ft^3	73,300	73,300	66,700	81,800
Average dust concentration $\frac{\text{micrograms}}{ft^3}$	13.6	6.8	183.1	6.5

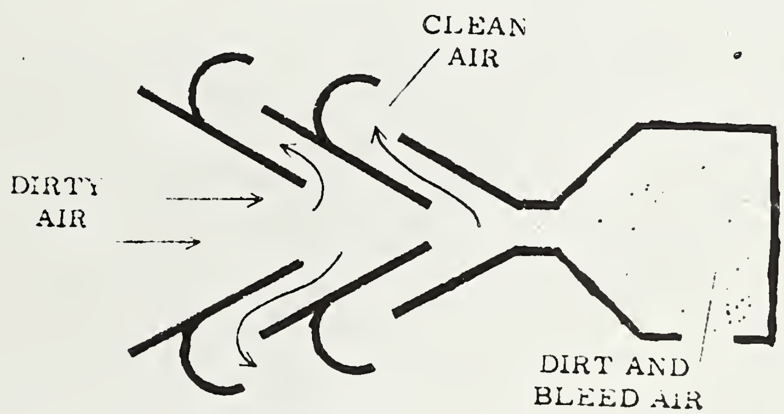
$$\text{Arrestance} = 100\ (1 - \frac{6.8}{13.6}) = 50 \text{ percent}$$

	Main duct	"Clean" duct	Exhaust duct	Work area
Unit 2B				
Total dust collected (21.5 hrs.) g	1.975	1.640	18.181	1.316
Percent lint	15	25	45	16
Total air sampled - ft^3	64,800	70,600	52,400	75,200
Average dust concentration $\frac{\text{micrograms}}{ft^3}$	30.5	23.2	346.7	17.5

$$\text{Arrestance} = 100\ (1 - \frac{23.2}{30.5}) = 24 \text{ percent}$$

DESCRIPTION

A Dyna Vane Air Cleaner is made up of one or more Dyna Vane cells. Each cell is essentially wedge shaped; the two converging sides consisting of a series of identical, equally spaced blades which provide narrow passages through which (clean) air can flow. The wide end of the wedge shaped cell is the front face or air inlet. The narrow opposite end of the cell is a rectangular outlet through which the dirt particles and bleed air can pass. This outlet opens into a tapered duct designed to collect and carry away the separated dirt particles.



The blades or louvers in the converging sides of the cell are a unique design which includes integral turning vanes as shown in the inset drawing.

Figure 1 Illustration of Dyna Vane from Farr Company Manual F190B.

Figure 2 Shakeout area on first floor served by Dyna Vane Units 1A and 1B. Intake vents for 1B are close to walkway level on the left. Room air samples were taken from a point close to the vertical duct midway down the walkway on the left.

Figure 3 Intake side of Dyna Vane 1B showing circular 22" duct bringing air up from the work area.

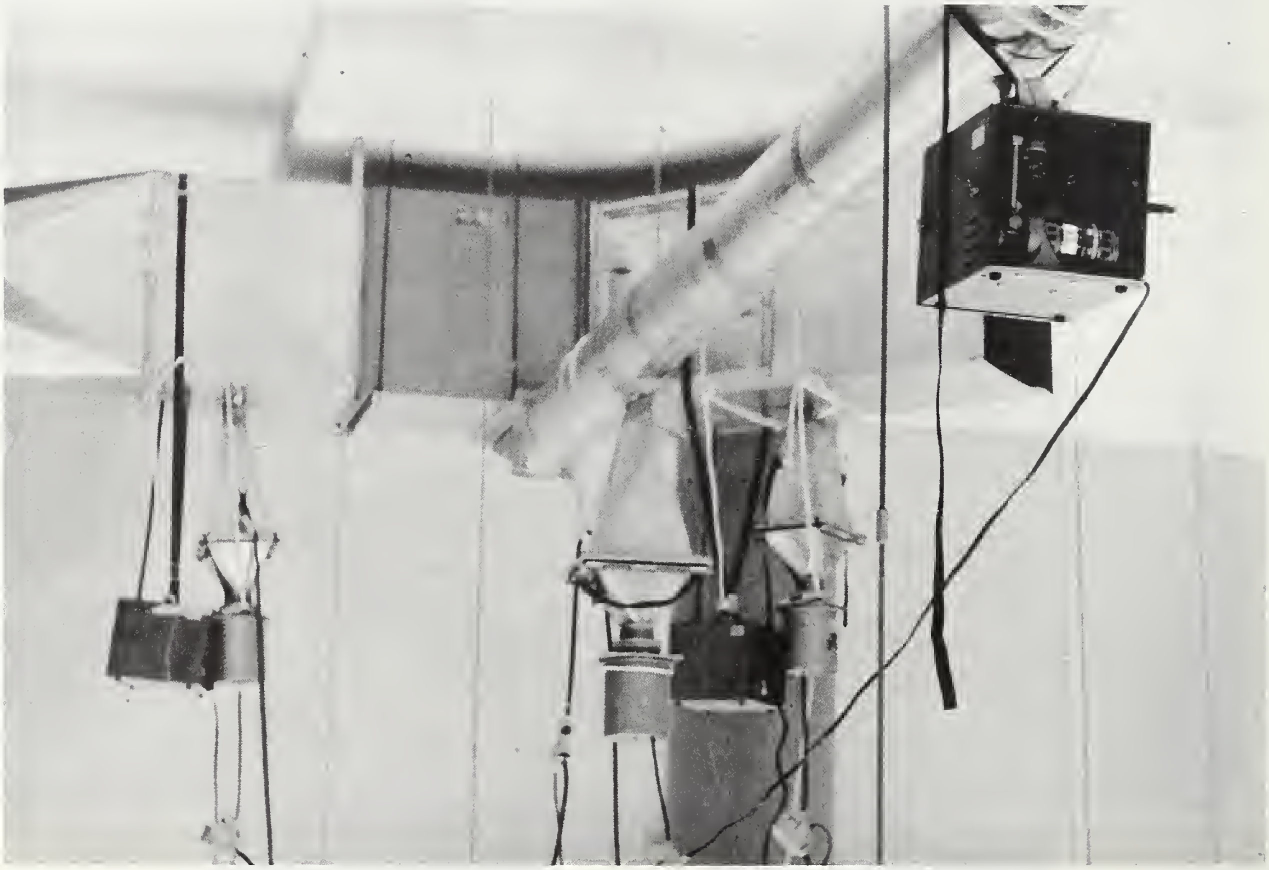


Figure 4 Dyna Vane 1B showing the paper tape samplers and high volume samplers in place.

Figure 5 Dyna Vane 1B showing where the main stream enters the unit (upper right), the clean air enters the room (upper left), and part of the 8" circular exhaust duct which carries dirty air from the building. The exhaust goes through a 90° turn to the left just beyond the point included in the photo.

Figure 6 High volume sampler drawing air from room near Unit 2B. The "Sack Central" area is about 6 ft. above and 10 ft. to the left of the sampler shown in the foreground. The sampler drawing air from the main stream of Unit 2B is inside the rectangular duct shown in the upper right.

Figure 7 Circular duct leading up to Dyna Vane Unit 2B. The main stream sampler is inside the lower rectangular duct about 5 ft. from the 90° bend.

Figure 8 Dyna Vane 2B showing part of the centrifugal fan just ahead of the unit and showing the bends in the clean air duct and the rectangular 4" x 16" exhaust duct just below the clean air duct.

Figure 9 Dyna Vane 2B showing the clean air duct (upper center) and 4" x 16" rectangular exhaust duct with high volume sampler in place. The clean air sampler is inside the duct about 3 ft. from the opening. The railing to the stairs leading to the "Sack Central" is shown in foreground.

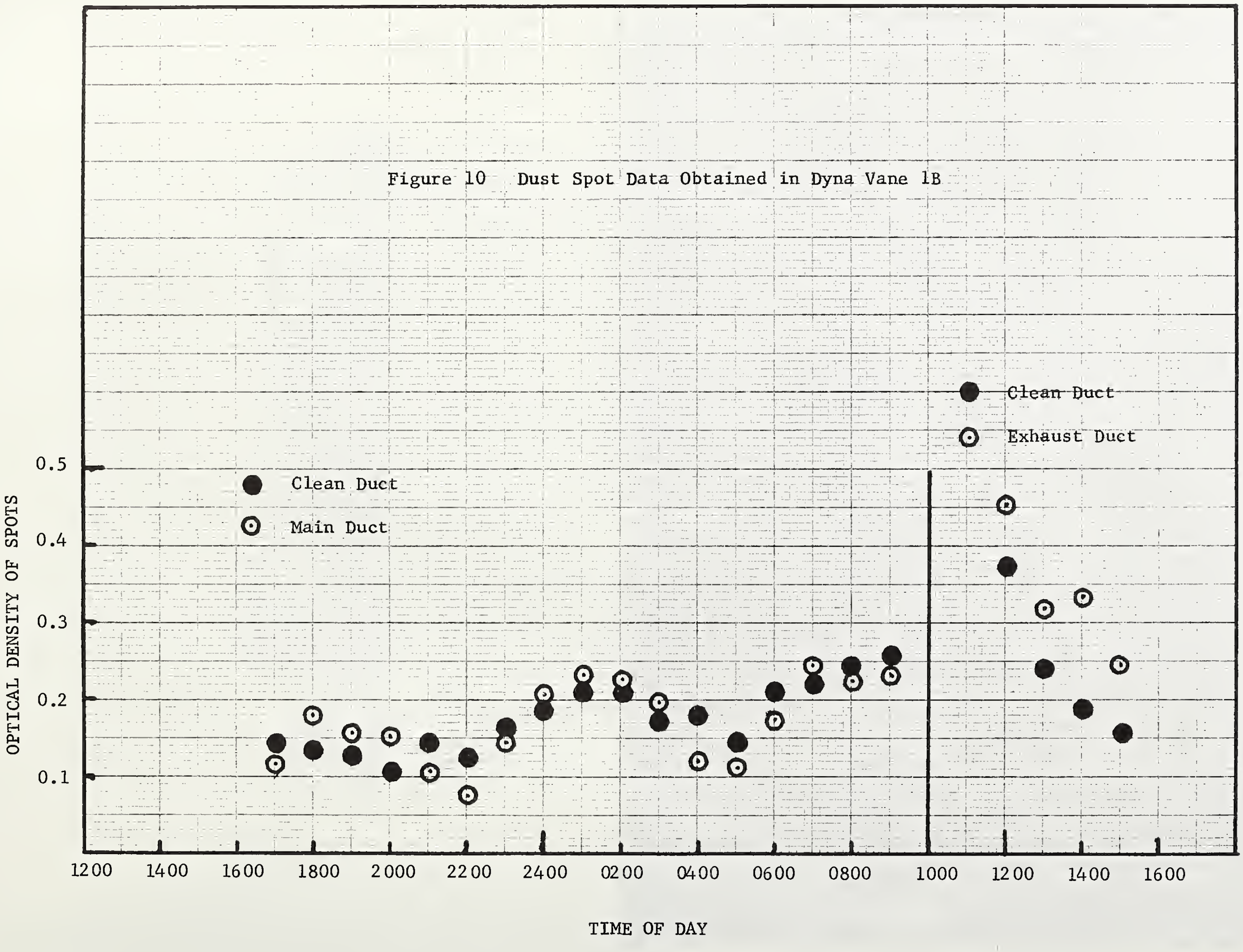


Figure 10 Dust Spot Data Obtained in Dyna Vane 1B
Clean Duct
Main Duct
Clean Duct
Exhaust Duct
OPTICAL DENSITY OF SPOTS
0.5
0.4
0.3
0.2
0.1
1200
1400
1600
1800
2000
2200
2400
0200
0400
0600
0800
1000
1200
1400
1600
TIME OF DAY

Figure 11   Samples of dirt collected by high volume samplers. Upper samples are from Unit 1B and lower samples from 2B.

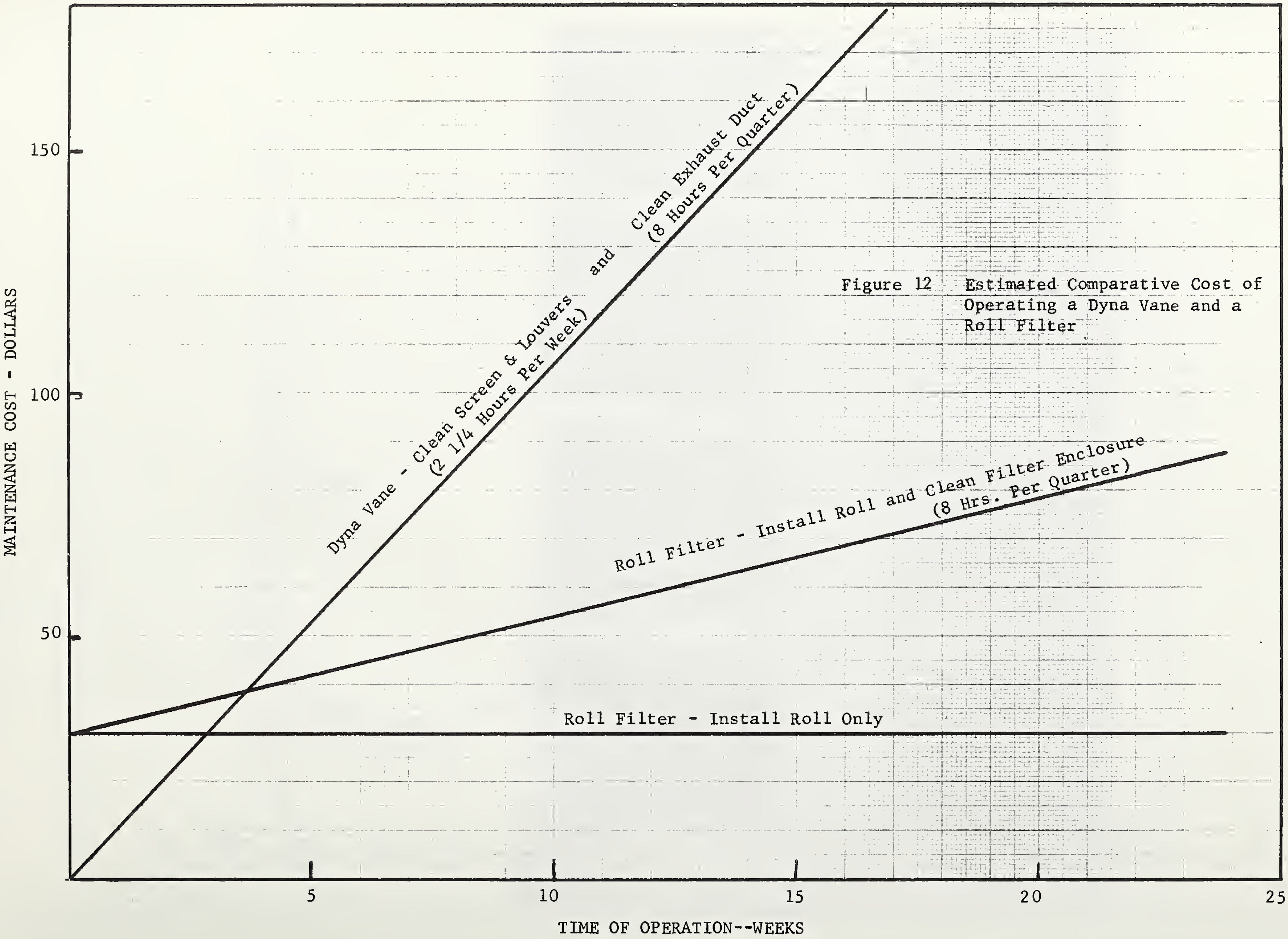


Figure 12 Estimated Comparative Cost of Operating a Dyna Vane and a Roll Filter

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